

Biogeochemistry of the Pond B Water Column, Savannah River Site, South Carolina

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Pond B at Savannah River Site (SRS) is an ideal location for examining the biogeochemical cycling of Fe, Pu, organic matter, and other metals in a monomictic stratified pond. This pond received reactor cooling water from 1957–1964 containing trace levels of radionuclides. Since then, Pond B has remained relatively isolated except for a few studies conducted in the late 1980s, which demonstrated Pu cycling with seasonal anoxia.

During summer thermal stratification, aqueous concentrations of Pu, Fe and ¹³⁷Cs increase with depth coupled with anoxia, low Eh, and high suspended solids, likely linked to reductive dissolution of Fe-(oxy)hydroxides and mobilization of organic matter. These trends are consistent with 1983 measurements of ^{239,240}Pu and ¹³⁷Cs activities in Pond B, although Pu and decay-corrected ¹³⁷Cs activities have since decreased 2- to 3-fold in the water column. Pu isotopic ratios in water samples are consistent among all locations and depths and are similar to ratios of upstream sediments, suggesting that Pu in the pond is dominantly from historical releases and not atmospheric fallout.

The microbial community was also examined to understand biotic mechanisms that impact Pu and Fe cycling. We observed that during stratification, the Pond B water column microbiome varies with depth rather than spatial location and can be broadly categorized by the three distinct stratification layers. Metal (e.g., iron) oxidizers/reducers were prevalent during stratification, likely influencing Pu immobilization onto Fe-(oxy)hydroxides in the thermocline and Pu mobility/reduction in the deep, anoxic layer. Notably, Fe(II) oxidizers were most abundant in the hypoxic/anoxic zones, while Fe(III) reducers dominated the deep, anoxic layer. In contrast to summer stratification, during spring turnover, the microbiome is homogenized throughout Pond B, reflecting the uniform geochemistry (e.g., oxygen concentrations, temperature, metals). We also observed a shift in the distribution and abundance of organic molecules (dissolved organic matter; DOM) with depth and location. Multivariate analysis based on bulk molecular parameters and relative abundance of individual elemental formulas showed that the molecular composition of DOM was highly stratified and could be separated into three distinct layers in the summer. Surface layer samples were characterized by higher nominal oxidation state of carbon, H/C, and aliphatic compounds. In contrast, the deep anoxic zone was characterized by higher DBE (double bond equivalent), DBE/O, aromatic index, and CRAM (carboxyl rich alicyclic molecules), indicating that the DOM in the deep layer was more refractory.